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2661

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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,303,631**, on March 31, 2000, by **CATENA TECHNOLOGIES CANADA, INC.**, assignee of Jim Hjartarson, Mark Feeley, Jonathan Boocock, Andrew Deczky and Andreas Weirich, for "A System and Method for Programmable Spectrum Management".

L. Lachance

Agent certificateur/Certifying Officer

July 19, 2001

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ABSTRACT

There is provided a line interface for coupling a twisted pair telephone line with a communications network comprising a broadband analog front end for coupling the twisted pair telephone line with the line interface, and a programmable filter for filtering frequency bands to separate transmission channels, the transmission channels located in the communications network, wherein the frequency bands are determined by the programmable filter.

A System and Method for Programmable Spectrum Management

The present invention relates generally to the field of Digital Subscriber Line Systems (DSL), and more particularly to a system and method for providing multiple systems simultaneously over a single subscriber line.

BACKGROUND OF THE INVENTION

Telephone operating companies have utilized twisted pair telephone lines to deliver telephone services to customers for over a century. There are roughly a billion twisted pair telephone lines worldwide that connect subscribers to their service providers. With the demand for increased bandwidth due to the emergence of new services such as high-speed connection to the Internet, new techniques to transmit broadband signals over the twisted pair have been developed. The twisted pair telephone line is now being used to deliver a wide variety of services using digital transmission techniques to subscribers in addition to the traditional telephony services that have always been provided.

The equipment that provides a broadband transmission capability over a twisted pair copper loop generally employs technology referred to as DSL (Digital Subscriber Line). DSL may be defined as a technology that enables communication using any number of methods that impress a signal representing a digital bit stream onto twisted pair loops traditionally used to carry POTS (Plain Old Telephone Service) signals. There are many different types of DSL that are currently in use including, but not limited to ISDN (Integrated Services Digital Network), ADSL (Asymmetric DSL), SDSL (Symmetric DSL), HDSL (High Speed DSL), VDSL (Very High Speed DSL).

Some DSLs such as ADSL allow POTS to coexist with the digital transmission. For instance ADSL operates in the frequency bands of 25 kHz to 138 kHz for upstream transmission and 138 kHz to 1104 kHz for downstream transmission. Upstream is generally defined as data flowing from a subscriber to a central office, whereas downstream is generally defined as data flowing from a central office to a subscriber. ADSL can coexist on the same twisted pair telephone line as POTS signals, which are typically in a frequency spectrum of roughly 0 to 4 kHz.

Figure 1 illustrates traditional central office line interface architecture for deploying ADSL with POTS, represented generally by the numeral 10. A twisted pair telephone line 12 terminates at a POTS splitter 14. The POTS splitter is coupled to an ADSL modem 16 and a POTS line interface 18. The POTS splitter performs a frequency dependent band splitting function. The splitter 14 separates ADSL frequencies, which are greater than 25 kHz, from POTS frequencies, which are less than 4 kHz. The ADSL frequencies are directed to the ADSL modem 16 while the POTS frequencies are directed to the POTS line interface 18.

Utilizing an integrated voice and data line interface can also provide the functionality described above. In this case, the functionality can be placed onto a single line interface, or line card. Figure 2 illustrates an example of such a line card, represented by the numeral 20. A twisted pair telephone line 12 terminates at the single line card 20. The telephone line 12 is coupled to an analog front end 22. The analog front end 22 is coupled to an analog-to-digital (A/D) converter 24, which is coupled to a digital splitter 26. The digital splitter 26 is coupled to both a data network interface 28 and a voice network interface 27. All the aforementioned components are located on the line card 20.

An analog signal is received over from the twisted pair telephone line 12 at the analog front end 22. The A/D converter 24 converts the analog signal to a digital signal, which is passed though the digital splitter 26. The digital splitter 26 separates the digital signal into a POTS signal and an ADSL signal. The POTS signal is communicated to a voice network via a voice network interface 27 and the ADSL signal is communicated to a data network via the data network interface 28. Although the band splitting function is illustrated as a digital function, it can be performed using either analog or digital filtering techniques.

The introduction of high-speed data transfer over twisted pair telephone lines is desirable for a large number of consumers. Although many residences have multiple telephone numbers, it is possible to accomplish this using one twisted pair telephone line. Therefore, most residences are wired with only a single twisted pair, making deployment of ADSL data services problematic for the service provider.

Currently, there are several methods used to combat this problem. These methods typically include the use of Pair Gain devices/Pair Gain devices Time Division Multiplex (TDM) signals from multiple users onto a single DSL signal. Therefore, each of the multiple users is

assigned a timeslot in the single DSL signal during which that can transmit data. However, these solutions lack flexibility and adaptability.

It is an object of the present invention to obviate or mitigate at least some of the above mentioned disadvantages.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a line interface for coupling a twisted pair telephone line with a communications network comprising a broadband analog front end for coupling the twisted pair telephone line with the line interface, and a programmable filter for filtering frequency bands to separate transmission channels, the transmission channels located in the communications network, wherein the frequency bands are determined by the programmable filter.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a block diagram of a typical ADSL line interface with splitter (prior art);

Figure 2 is a block diagram of an integrated ADSL line interface (prior art);

Figure 3 is a block diagram of an integrated ADSL line interface according to an embodiment of the invention;

Figure 4 is a graph illustrating different frequency bands with different, programmable band edges;

Figure 5 is a graph illustrating ADSL and POTS frequency spectrum allocation; and

Figure 6a, 6b, 6c, 6d, and 6e are graphs illustrating how an embodiment of the invention can be applied to ADSL applications.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

For convenience, like structures in the drawing are referred to using like numerals.

Figure 3 shows a subscriber line interface 60. The interface 60 terminates twisted pair telephone line 12 and is comprised of a broadband capable analog front end 62 coupled to an

A/D converter 64. The output of the A/D converter 64 is coupled to a programmable filter 66 for providing, which is coupled to a plurality of outputs 68.

A broadband signal is delivered by the twisted pair telephone line 12 and is processed by the broadband analog front end 62. The A/D converter 64 digitizes the broadband signal without any band splitting function. The programmable filter 66 is used to spectrally separate different frequency bands that can be separated into different data paths 68. Each of the data paths 68 has the capability to support different services. It is preferable that the programmable filter 66 is digital, however it is possible to use analog filtering.

Programmable filters are known in the art and therefore will not be described in detail. The programmable filter 66 is preferably capable of being programmed using software. Using software to program the filter 66 enables the filter 66 to be easily upgraded and modified. Since the programmable filter 66 is easily modified, the number of bands provided for different services can be changed as necessary without concern for adapting the line interface 20 itself. Therefore the system control is implemented in software and the equipment can be easily maintained and updated as necessary. Since the software can be downloaded to the filter, the need to remove the line card for the purpose of upgrading it is reduced. This versatility is aided by allowing flexibility in the utilization of bandwidth on the twisted pair telephone line 12.

This approach can be applied to any of a number of different services that can be transported over various transmission techniques occupying different frequency bands on the twisted pair. In figure 4 a generic form of this approach is shown. N different services are carried in N different frequency bands, each with potentially different modulation schemes. Using different modulation schemes allows support of a variety of potential services to occupy different programmable frequency bands. Different modulation schemes may be used since the filter only filters the bands and routes them to an appropriate service. The filter is programmed to send each band to its appropriate service where the required modulation and demodulation schemes are applied.

Referring once again to figure 3, different digital bit streams that are carried in different frequency bands are separated into different paths 68 and delivered to different service providers (not shown). The bit streams can represent either a raw digitized version of the analog signal or a fully demodulated data stream occupying a particular frequency band.

The approach described in this embodiment of the invention allows flexibility in several aspects described below. It is possible to add new services occupying new frequency bands. Different modulation schemes in each of the different frequency bands can be used to exploit channel characteristics and service requirements. Also, band edges can be moved to support introduction of new standards or enhancement of existing standards as well as for exploiting channel characteristics such as avoidance of single frequency disturbers. All of these characteristics allow different service providers to have access to the twisted pair.

In an alternate embodiment, programmable spectrum management can be used with the traditional integrated line shown Figure 2 for increasing data throughput when the POTS line is on hook (not in use). Figure 5 shows the frequency bands utilized for ADSL upstream, ADSL downstream, and POTS signals. The band edges for both full rate ADSL and G.Lite ADSL implementations are indicated in table 1 below, but can be extended to cover other non-standards based versions of ADSL. The POTS signal typically ranges between 0 and 4 kHz.

	x_3	x_4	x_5	x_6
G.Lite	25kHz	138kHz	138kHz	552kHz
Full Rate	25kHz	138kHz	25kHz	1104kHz
Full Rate (with reduced NEXT)	25kHz	138kHz	138kHz	1104kHz

Figure 6 illustrates how the present embodiment of the invention can be applied to ADSL applications. Figure 6(a) shows typical POTS and ADSL frequency allocations. The bandwidths are the designated as described for figure 5. The 4kHz bandwidth allocated for POTS is utilized only when the POTS interface is off hook. However, when the POTS interface is on hook the 4 kHz POTS bandwidth is not in use. It is common in the art to provide a signal indicating whether the POTS interface is on hook or off hook. By providing this signal as an input to the programmable filter, the bandwidth of an ADSL upstream signal can be extended as follows. If the POTS interface is off hook, the programmable filter extends the lower band edge of the ADSL upstream signal to include frequencies between 0 and 25kHz as shown in figure 6(c), thereby increasing the upstream throughput. If the POTS interface is on hook, the programmable filter returns the lower band edge of the ADSL upstream signal to 25kHz.

Alternately, the POTS may be provided as a derived service and carried in the DSL bit stream. Such a scheme is used, for example, for pair gain systems. Therefore, as illustrated in figure 6(b), the 4kHz POTS bandwidth is unused. Although it is desirable to extend the lower band edge of the ADSL upstream signal to 0kHz, it is not practical. In the event of a failure, such as a power outage or hardware error, it is necessary to revert such a derived since to a POTS service. This failsafe is often referred to as "fail to POTS mode" and provides telephone service in case of an emergency. Therefore, the 4kHz POTS bandwidth has to be left open should such a failure occur. In order to operate properly, such a system requires a signal for indicating whether the system is operating normally or in fail to POTS mode. Therefore, providing this signal to the input of the programmable filter allows the filter to extend the lower band edge of the ADSL upstream signal. If the system is operating properly the programmable filter extends the lower edge of the ADSL upstream signal to 0kHz. If the system is operating in fail to POTS mode, the programmable filter returns the lower band edge of the ADSL upstream signal to 25kHz.

While the above only describes extending the lower edge of the ADSL upstream signal, it is further possible to move the upper band edge of the ADSL upstream signal as well as both band edges of the ADSL downstream signal. The moveable band edges are illustrated schematically in figure 6(d). Therefore, the 25kHz gain in bandwidth may be transferred to the ADSL downstream signal by moving the upper edge of the ADSL upstream signal and the lower edge of the ADSL downstream signal 25kHz lower. Other configuration may be achieved as desired.

Furthermore, allowing dynamic movement of the band edges can be used for providing more symmetrical data rates as well as allowing the edges to be moved according to the requirements of a particular system. For example, if there is a demand for an upstream signal with a broader bandwidth, then the downstream signal bandwidth could be narrowed and vice versa. In yet another example, the bandwidths can be easily changed to accommodate changing standards by simply reprogramming the programmable filter.

Alternately, other services in addition to POTS and ADSL may be carried by the twisted pair telephone wire as shown in figure 6(e). Such services could be added to frequency bands above the ADSL downstream signal.

Although the invention has been described with reference to certain specific embodiments, various modifications thereof will be apparent to those skilled in the art without departing from the spirit and scope of the invention as outlined in the claims appended hereto.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A line interface for coupling a twisted pair telephone line with a communications network:
   a broadband analog front end for coupling said twisted pair telephone line with said line interface; and
   a programmable filter for filtering frequency bands to separate transmission channels, said transmission channels located in said communications network;
   wherein said frequency bands are determined by said programmable filter.

2. A line interface as defined in claim 1, wherein said communications network comprises a data network and a voice network.

3. A line interface as defined in claim 1 further comprising an analog to digital converter for converting said analog signal to a digital signal, and wherein said programmable filter is a digital programmable filer.

4. A line interface as defined in claim 1, wherein said transmission channels are directed to different service providers.

5. A line interface as defined in claim 4, wherein said transmission channels comprise signals with different modulation schemes.

6. A line interface as defined in claim 1, wherein said programmable filter is programmed with software.

7. A line interface as defined in claim 6, wherein said software is downloaded to said programmable filter.

8. A line interface as defined in claim 1, wherein said frequency bands are determined according to a protocol selected from a group comprising POTS, ISDN, ADSL, VDSL, SDSL, IDSL, HDSL, and HDSL2.

9. A line interface as defined in claim 8, wherein said ADSL is selected from a group comprising full rate ADSL, G.Lite, CAP, and QAM.

10. A line interface as defined in claim 9, wherein said ADSL and said POTS coexist on said twisted pair telephone line.

11. A line interface as defined in claim 10, further comprising an usage signal for determining if a POTS bandwidth is in use, said signal being coupled to said programmable filter as an input.

12. A line interface as defined in claim 11, wherein an ADSL bandwidth is expanded to include said POTS bandwidth when said usage signal indicates that said POTS bandwidth is not in use, and said ADSL bandwidth is reduced to exclude said POTS bandwidth when said usage signal indicates said POTS bandwidth is in use.

13. A line interface as defined in claim 11, wherein said usage signal determines if a telephone connected to said twisted pair telephone wire is on hook or off hook.

14. A line interface as defined in claim 11, wherein said usage signal determines if a POTS signal is communicated in said ADSL bandwidth or if said POTS signal is communicated in said POTS bandwidth.

15. A method for providing a plurality of services over a twisted pair telephone line comprising the steps of:

receiving a broadband analog signal from said twisted pair telephone line;

filtering said broadband analog signal using a programmable filter for providing a plurality of separate bands; and

transmitting said separate bands to a plurality of different service providers.

16. A method as defined in claim 15, wherein said separate bands are transmitted to said plurality of different service providers through a data network and a voice network.

17. A method as defined in claim 15, wherein said programmable filter is upgraded by programming said filter with software.

FIG 1

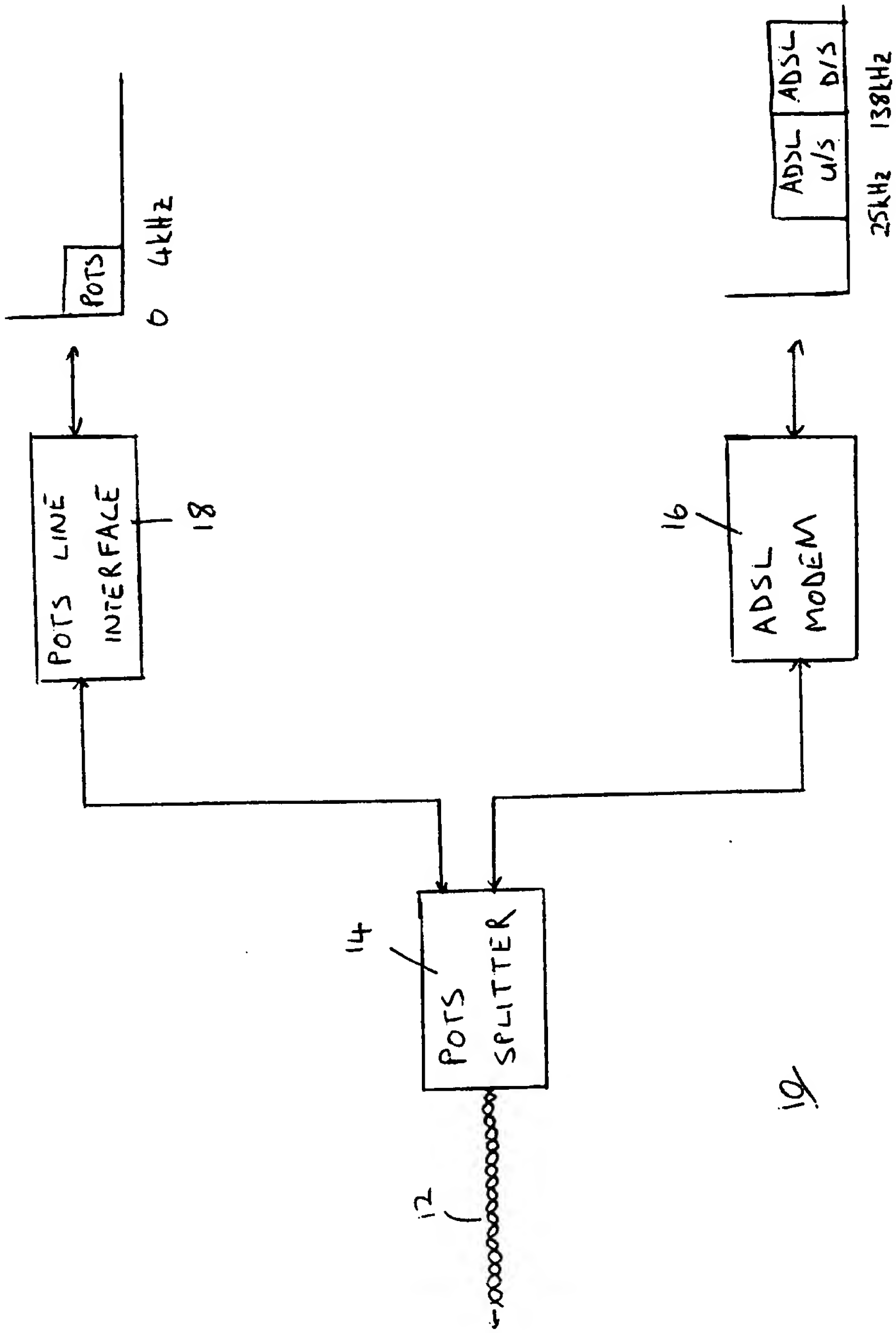
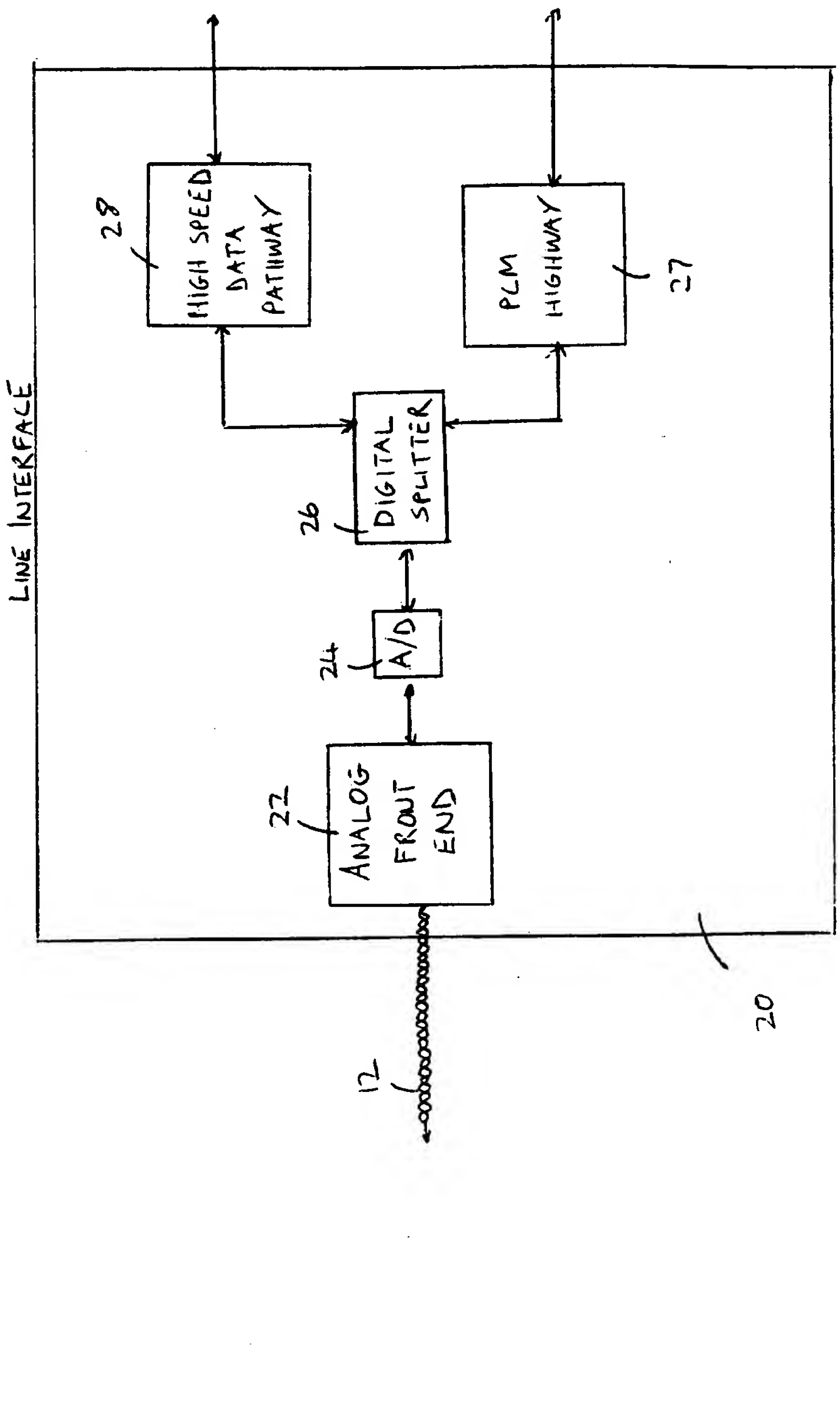

POTS
0
4kHz
ADSL U/S
ADSL D/S
25kHz
138kHz
POTS LINE INTERFACE
18
ADSL MODEM
16
POTS SPLITTER
14
12
10

FIG 2


LINE INTERFACE
HIGH SPEED DATA PATHWAY
28
PCM HIGHWAY
27
DIGITAL SPLITTER
26
A/D
24
ANALOG FRONT END
22
20
12

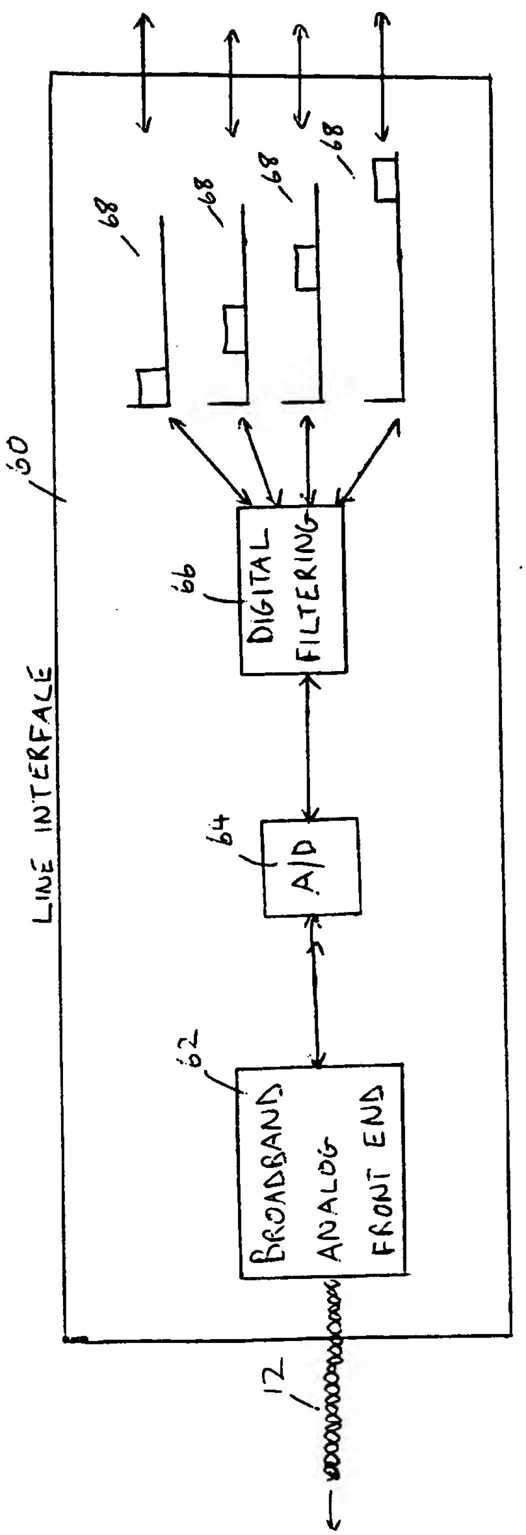
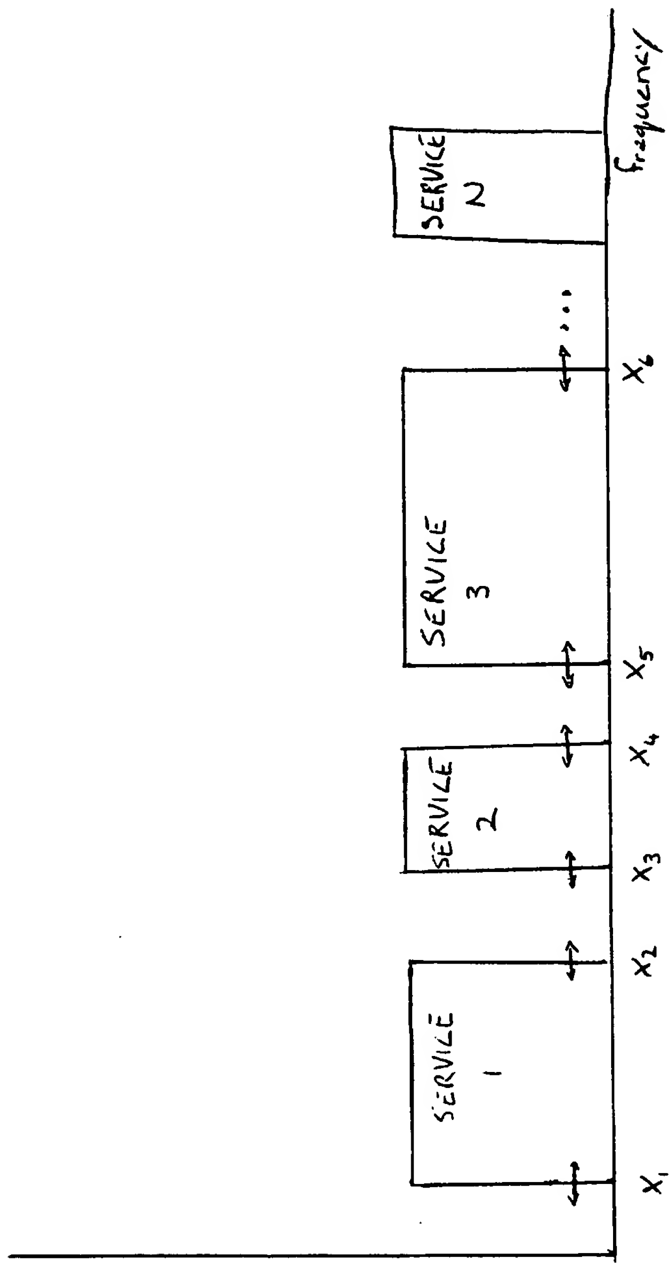

LINE INTERFACE
60
BROADBAND ANALOG FRONT END
62
A/D
64
DIGITAL FILTERING
66
68
68
68
68
12

FIG 3

FIG 4


SERVICE
N
SERVICE
3
SERVICE
2
SERVICE
1
Frequency
X_1
X_2
X_3
X_4
X_5
X_6

CA 02303631 2000-03-31

FIG 5

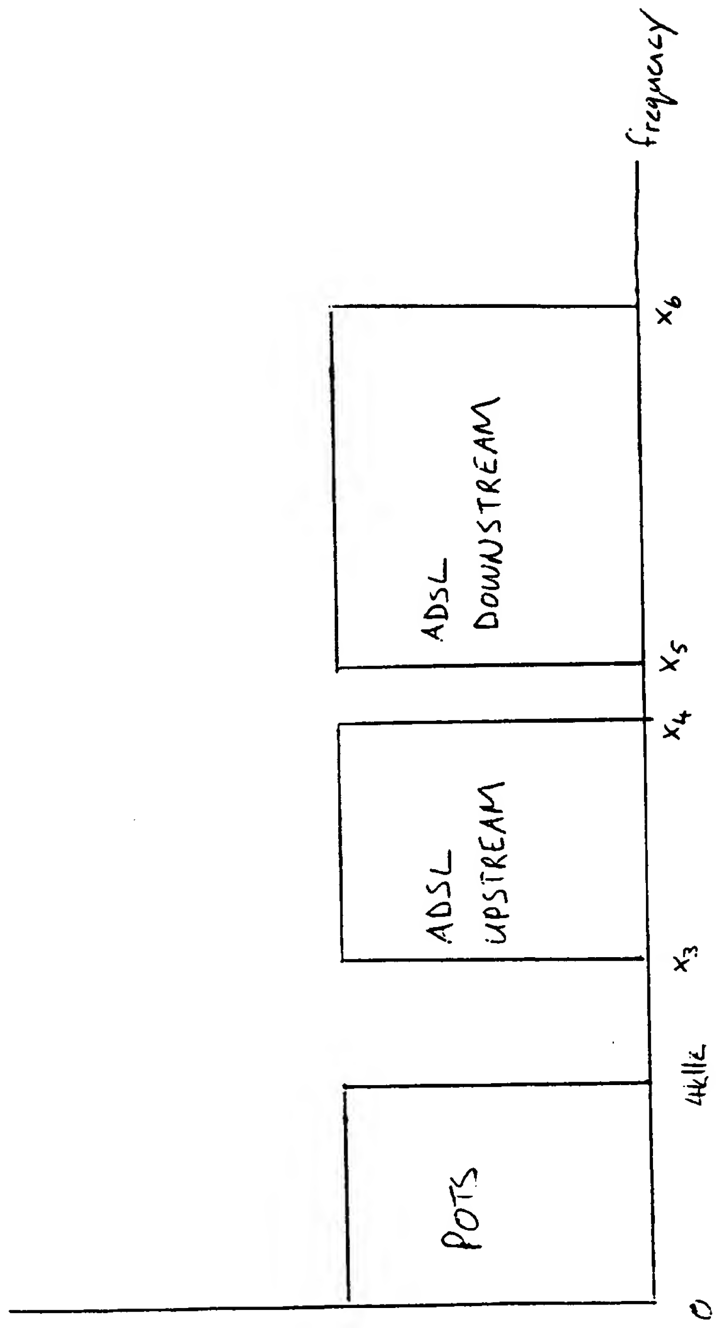
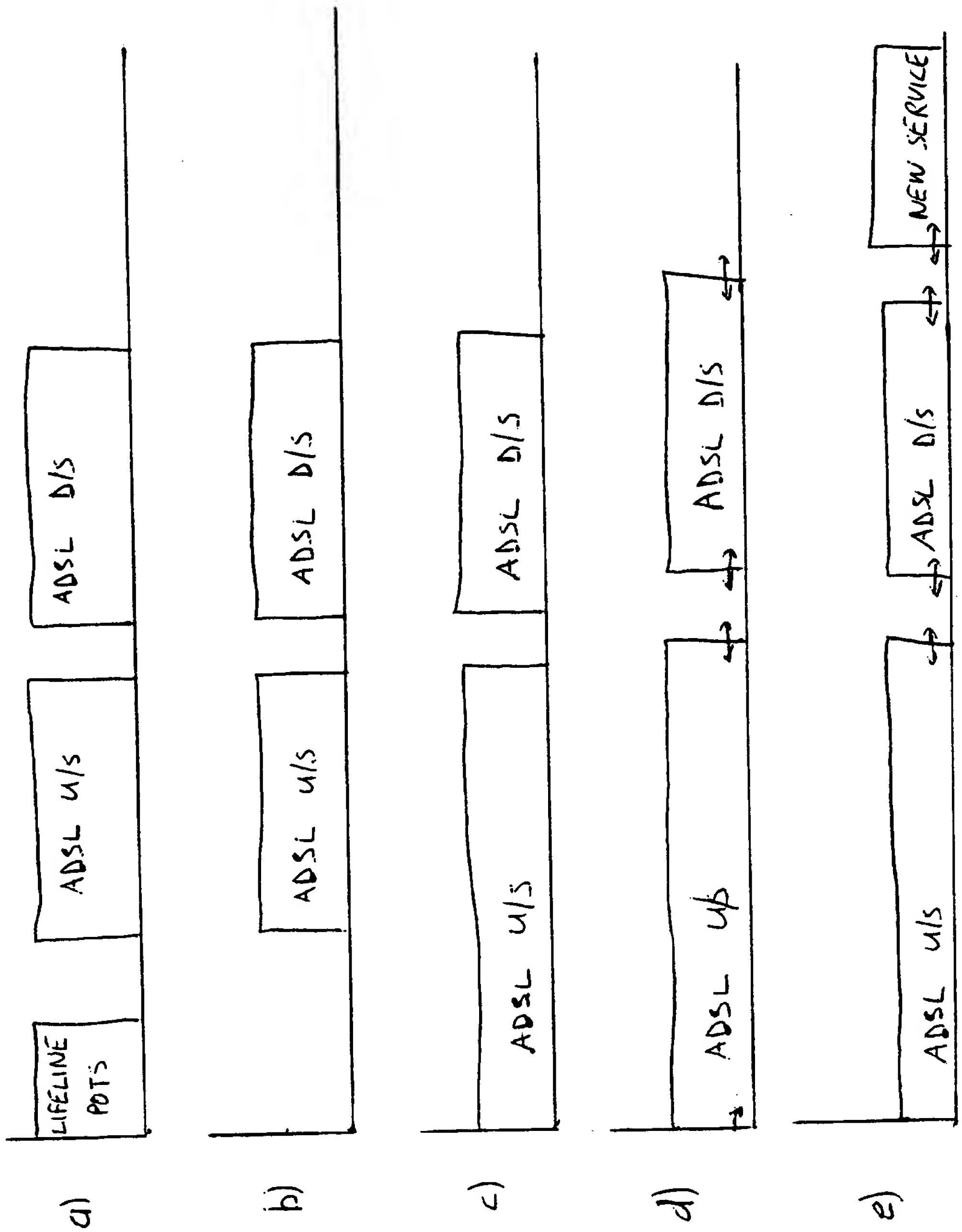


FIG 6


a)
LIFELINE POTS
ADSL U/S
ADSL D/S
b)
ADSL U/S
ADSL D/S
c)
ADSL U/S
ADSL D/S
d)
ADSL U/S
ADSL D/S
e)
ADSL U/S
ADSL D/S
NEW SERVICE

Kenneth R. Allen, Reg. No. 27,301 (650) 326-2400
Application No.: 09/810,938 Filed: 03/16/01
Examiner: Unassigned
Art Unit: 2661
Title: A System And Method For Programmable Spectrum Management
Attorney Docket No.: 020510-13.00US

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